most stable results are usually secured through gradual evolution, and the Washington Memorial Institution can grow as rapidly as circumstances permit. Should there be a congressional cataclysm in favor of a national university, a foundation will be at hand which will obviate the necessity of erecting castles in the air.

The action of the National Council of Education in somewhat brusquely setting aside the report of its committee, and that of the National Educational Association in affirming its position in favor of a national university, certainly represent a strong trend of opinion. More especially are the representatives of the great State universities in favor of a national university, and these universities are the allies of the future. We are in the midst of conditions that have not existed elsewhere or heretofore. Our privately endowed colleges and universities originated largely in sectarian enthusiasm, and are still in large measure supported by adherents of special religious denominations. The unexampled gifts of rich men for public education have undoubtedly tended to maintain the stability of society and have bridged over the interval required for the people to learn the importance of higher education for the common good. But we shall not always depend on the charity of the rich, nor will our universities always be administered by business men. Pennsylvania, Johns Hopkins and Cornell are turning to the State for help; Harvard, Yale and Columbia must do the same if their prestige is to be maintained.

The obvious outcome of democratic institutions is the support of education by the people. We have district schools, city colleges and state universities. We shall have a University of the United States. It may come suddenly, but it is far more likely to result from the gradual development of the Washington Memorial Institution.

J. MCKEEN CATTELL.

SHORTER ARTICLES.

SOME OBSERVATIONS BEARING ON THE PROBABLE SUBSIDENCE DURING RECENT GEOLOGICAL TIMES OF THE ISLAND OF SANTA CATALINA OFF THE COAST OF SOUTHERN CALIFORNIA.

IN the course of the dredging operations carried on along the coast of southern California by the Zoological Department of the University of California, during the past summer, observations were made incidentally of such obvious geological interest that I feel justified in going outside my own province to record them.

While dredging in forty-five fathoms about three-quarters of a mile off Long Point, on the north side of Santa Catalina Island, the dredge brought up large numbers of cobble stones varying in size from a sparrow's egg to a man's head. Most of them were very smooth and round, though they were covered by a thick coating of encrusting bryozoa, worm tubes, ascidians, chitens, sponges, etc., showing them to have remained undisturbed for a long period.

They were entirely similar in material and shape and size to the cobbles composing the shingle of many of the little beaches on different parts of the island, *e. g.*, that at Avalon near by.

That they came from a submerged beach was a suggestion so obvious as not to escape any of those on board the launch, in spite of the fact that there was not a geologist among us, and hence no one greatly familiar with the geological history of the region, and consequently prepared to put such an interpretation on what we saw.

When, however, we came to consider the matter in the light of facts of a wholly different character well known to geologists, and understood by them to testify that the island has been sinking beneath the waters of the Pacific in recent geological time, there would seem to be little doubt that at no very remote date in the past, geologically speaking, the *shore line of the island at the point from which these stones were taken was from three-quarters of a mile to a mile out to sea from its present position.*

The subject is so interesting as to make it worth while to present in outline the evidence from other sources tending to show that a subsidence of the island *has* taken place even if it is not still in progress.

It is now generally admitted among geologists, I believe, that San Pedro Hill on the mainland has emerged from the sea and been elevated to its present height, 1475 feet, since Post-Pliocene times. The hill, particularly on its seaward slope, is laid off into a succession

of remarkably clear-cut steps, or benches, one above another, to the number of ten in all, according to Professor Lawson. On approaching it from the sea one's imagination easily makes it the terraced grounds ages ago deserted and fallen into ruins, of one of Cronus' country seats before that crafty monarch was overthrown by all-powerful Zeus.

Professor A. C. Lawson* has brought forward arguments that are, I should think, conclusive, in support of the view that these steps are marine wave-cut terraces; that they mark the position of the ocean strand at successive periods during the elevation of the hill.

The island of San Clemente, 1,964 feet high, lying sixty miles to the southwest of San Pedro Hill, is very similar to it in topographical features, particularly as regards the terraces, the chief difference being that the terraces of the island are more sharply defined and more numerous than those of the Hill. The evidence is, then, that both the mainland of the coast, and San Clemente island emerged simultaneously from the sea.

Now the island of Santa Catalina, lying midway between the two, is wholly different from either of them topographically. It is a mountain mass as bold and jagged as one often sees, and terraces are entirely wanting. The same sally of the imagination that makes San Pedro Hill the country seat of King Cronus makes Santa Catalina Island the site of his castle; for not only have we here the rock upon which the castle stood, but in San Pedro channel, a hundred fathoms deep at not much beyond an arrow's flight from the rocky walls, we have also the moat of the castle.

The contrast between Catalina and the two land masses between which it is situated cannot be better brought out than by Professor Lawson's own words: "In all the physiographic wonderland of Southern California," he writes, "there is probably nothing more surprising than the contrast which the topography of Santa Catalina presents to that of both San Pedro Hill and San Clemente. Lying midway between the two latter insular masses, in the same physiographic province, and affected by the same climatic conditions, Santa Catalina might, *à priori*, be supposed to differ from these but little in the character of its land sculpture. This supposition proves, however, to be fallacious. The difference between the aspect of the island and that of the two other neighboring insular masses is amazing, and the hypothesis which we are forced to entertain to account for it, is correspondingly startling."

The writer then proceeds to bring forward cogent arguments in support of the proposition that "*Santa Catalina was a land-mass, subject to the forces of subaerial degradation, at the time when San Pedro Hill and San Clemente began to emerge from the waters of the Pacific, in Post-Pliocene time.*"

But not only this. He finds further strong evidence, on physiographic grounds alone, that not only was the island full-born when the neighboring land masses began to emerge from the sea, but that while the latter have been undergoing elevation *Catalina itself has been subject to a process of submergence.*

In this latter view the author is defending a suggestion made by Dr. J. G. Cooper, the pioneer California naturalist who explored the island in 1863 as geologist of the California State Geological Survey.

With the addition of the evidence produced by our dredgings this summer to that brought forward by Professor Lawson, it would seem that the subsidence hypothesis reaches well nigh a demonstration.

It should be said that some of the fishermen at Avalon have known for a number of years of the existence of this particular bed of cobble stones, and it is asserted by them that the bed extends out to seventy-five fathoms.

Time would not permit us to trace out the full extent of bed. Similar cobbles were brought up at other points around the island, though not so abundantly as here; but it should be stated that most of our work here was done with the beam trawl, as this was found better adapted to our biological work. It is, however, much less likely to pick up such stones than is the dredge.

It is highly probable that careful dredging

* 'The Post-Pliocene Diastrophism of the coast of Southern California,' *Bulletin of the Department of Geology*, University of California, Vol. I., No. 4, 1893.'

with this as the primary object will discover similar evidence of submerged shingle beaches at many other points around the island.

WM. E. RITTER.

UNIVERSITY OF CALIFORNIA,
Sept. 7, 1901.

ZONE OF MAXIMUM RICHNESS IN ORE BODIES.

FOR a long time, and among many mining people, the theory has prevailed that ore deposits have been derived from the interior of the earth, the mineral materials being carried upward to the surface by means of heated solutions. As a result, a maxim has been established that ore bodies necessarily get richer as depth increases. The fact that many exceptions have been found to this rule is ascribed to peculiar local conditions.

Aside from the bare statement of the general rule, no limitations have been formulated by the mining men. It has remained for the geologists to reach measurable results regarding the relative richness of ore bodies at varying depths. The results are not only very satisfactory, but they are totally at variance with the commonly assumed formulæ. Late investigations demonstrate, both theoretically and practically, that the problem has been wholly misunderstood by miners; and that the so-called empirical rule has very decided limitations.

Contrary to opinions heretofore generally held, many, if not most, ore bodies are believed not to be formed by the materials coming up in a superheated condition from great depths to the surface of the earth. Revolutionary as it may seem to many who have not followed carefully the trend of recent investigation, it appears to be a fact, nevertheless, that ore bodies are to be regarded as deposits formed very near the surface of the earth's crust; or, to be more precise, formed only in that thin outer part of the zone of the lithosphere which geologists are pleased to call the zone of fracture. Unusual richness which many ore deposits show at very shallow depths has come to be looked upon as due to local enrichment long after the first concentration has taken place.

Careful study of important ore bodies indicates that after a certain depth is reached, there is frequently a very marked decrease in the amount of ore material, until finally in some cases the ores become too lean to work. From the point of view of origin, diminution in richness with depth is not, then, to be regarded as an actual depreciation in grade of the ore. The real status of the case is that the original deposition of the ore has in the upper zone undergone a greater or less augmentation in metallic content since the ore bodies first began to form.

As distinct processes, the rival theories of ascending solutions, descending solutions and laterally moving solutions no longer find countenance among those who have given the subject of ore genesis most attention, and especially among those who have approached the subject from the geological side. Ore deposition may take place through all three means, which may have equal importance. After an ore deposit has once formed under special geological conditions, the secondary enrichment which it may undergo is believed to take place largely under the influence of the descending solutions. Therefore, in the exploitation of ore bodies, everything goes to show how vitally important is a full consideration of the geological structures presented, both at the time of the first concentration and as subsequently assumed.

Under the title of 'Enrichment of Mineral Veins by Later Metallic Sulphides,' in the recently issued Volume XI. of the *Bulletin* of the Geological Society of America, Mr. W. H. Weed gives the results of his investigations concerning the zones of maximum richness in ore bodies. Briefly stated, the attempt is made to prove: (1) that the leaching of a relatively lean primary ore, commonly by surface waters, will supply the material in solution for such enrichment; (2) that the unaltered sulphides, especially pyrite, will induce precipitation, that the material precipitated is crystalline, and that a number of mineral species are commonly formed, and are now forming, in veins by such reactions; and (3) that such minerals deposited in quantity may form ore bodies of considerable size (bonanzas), or may be disseminated through the lean primary ore in strings and patches, thus enriching the ore body as a whole and